CLAIMS

1. An article of manufacture comprising:

a first component comprising a composition having a formula $Li_xM_yN_zO_2$, wherein M is a metal atom or a main group element, N is a metal atom or a main group element , x, y and z are all numbers in the range of about >0 to about 1, and y and z are such that a formal charge on a M_yN_z portion of the compound is (4-x), providing that where one of M or N is Ni the other may not be Al, B or Sn, and further provided that where one of M or N is Co the other may not be Al, B, Sn, In, Si, Mg, Mn, Cu, Zn, Ti or P;

an electrically conductive material in electrical communication with the first component; and

a lithium ion conductive, dimensionally supportive matrix positioned to allow lithium ion communication with the first component.

2. An article of manufacture according to claim 1, wherein the first component crystallizes in an α-$NaFeO_2$, an orthorhombic $LiMnO_2$ or a tetragonal spinel $Li_2Mn_2O_4$ structure.

3. An article of manufacture according to claim 1, wherein the article of manufacture is a cathode.

4. An article of manufacture according to claim 1, wherein the electrically conductive material is carbon black.

5. An article of manufacture according to claim 1, wherein the lithium ion conductive, dimensionally supportive matrix is a lithium ion conductive polymer.

6. An article as in claim 1, wherein at least one of the electrically conductive material and the lithium ion conductive matrix is polymeric.

7. An article as in claim 6, wherein each of the electrically conductive material and the lithium ion conductive matrix is polymeric.

8. A polymer electrolyte comprising:

a non-crosslinked association of a plurality of block copolymer chains each including at least one ionically-conductive block and at least one second block immiscible with the ionically-conductive block;

the association amorphous and non-glassy through the entire range of at least from about 0°C to about 70°C; and

the chains arranged in an ordered nanostructure including a continuous matrix of amorphous domains defined by association of ionically-conductive blocks providing continuous ionically-conductive pathways, and amorphous second domains, immiscible with the ionically-conductive domains, defined by association of second blocks.

9. A polymer electrolyte as in claim 8, wherein the ordered nanostructure is formed upon reduction of temperature of a disordered melt.

10. A polymer electrolyte as in claim 8, wherein the ordered nanostructure is formed from a solution upon evaporation.

11. A polymer electrolyte as in claim 8, wherein the ordered nanostructure is formed from a solution upon precipitation.

12. A polymer electrolyte as in claim 8, wherein the ionically-conductive blocks form continuous, ionically-conducting domains when doped with an appropriate salt.

13. A polymer electrolyte as in claim 8, wherein the electrolyte is free of crosslinking, crystallization or glassification and the ordered nanostructure exhibits global dimensional stability and chain mobility providing high ionic conductivity.

14. A polymer electrolyte as in claim 13, wherein interblock, non-covalent chemical attractions create associations between the chains that allows for chain mobility providing high ionic conductivity while maintaining dimensional stability.

15. A polymer electrolyte as in claim 8, wherein the molecular weight of the block copolymer chains of the ionically-conductive polymer is at least about 10,000 Daltons.

16. A polymer electrolyte as in claim 15, wherein the molecular weight of the block copolymer chains of the ionically-conductive polymer is at least about 25,000 Daltons.

17. A polymer electrolyte as in claim 16, wherein the molecular weight of the block copolymer chains of the ionically-conductive polymer is at least about 50,000 Daltons.

18. A polymer electrolyte as in claim 17, wherein the molecular weight of the block copolymer chains of the ionically-conductive polymer is at least about 100,000 Daltons.

19. A polymer electrolyte as in claim 8, wherein the second block is ionically-conductive.

20. A polymer electrolyte as in claim 8, the second block including non-ionically-conductive acrylates selected from the group consisting of polydecyl methacrylate, polylauryl methacrylate, wherein decyl and lauryl can be replaced with moieties having a number of carbon atoms high enough that the glass transition temperature of the block is less than service temperature, and selected such that crystallization does not occur, polyalkyl acrylates, polydimethyl siloxane, polybutadiene, polyisoprene, and saturated polymers or copolymers derived from polybutadiene and polyisoprene such as polyethylethylene and polyethylenepropylene and copolymers thereof, and modified polystyrenes with flexible side chains of alkyl fluorocarbon and siloxane side chains attached through the phenyl group.

21. A polymer electrolyte as in claim 8, wherein the association of block copolymer chains is amorphous and non-glassy within a temperature range of at least from about -40°C to about 70°C.

22. A polymer electrolyte as in claim 8, wherein the second block has a Tg of less than about 0°C.

23. A polymer electrolyte as in claim 22, wherein the second block has a Tg of less than about -25°C.

24. A polymer electrolyte as in claim 23, wherein the second block has a Tg of less than about -40°C.

25. A polymer electrolyte as in claim 8, wherein the second block is electronically-non-conductive.

26. A polymer electrolyte as in claim 8, wherein the ionically conductive block is selected from the group consisting of methoxy polyethylene glycol methacrylate, methoxy polyethylene glycol acrylate, and other acrylate and methacrylate polymers modified to include short polyethylene oxide and polyethylene glycol side chains, polybutadiene or polyisoprene modified so as to include polyethylene oxide or polyethylene glycol side chains of length less than about 20 oxide units, polystyrene similarly modified through the phenyl group to include polyethylene oxide or polyethylene glycol side groups.

27. A polymer electrolyte as in claim 8, wherein the ionically-conductive domain incorporates an auxiliary ionic conductor.

28. A polymer electrolyte as in claim 27, wherein the auxiliary ionic conductor is polyethylene glycol dimethyl ether.

29. A polymer electrolyte as in claim 8, wherein the domains defined by association of ionically-conductive blocks define continuous ionic pathways due either to defects in the association, or inherent micro-phase separation.

30. A polymer electrolyte as in claim 8, doped with a lithium salt.

31. A polymer electrolyte as in claim 8, constructed and arranged as an electrolyte in a battery.

32. A polymer electrolyte as in claim 31, constructed and arranged as an electrolyte in an ionic solid state battery.

33. A polymer electrolyte as in claim 31, constructed and arranged as an electrolyte in a lithium solid battery.

34. A polymer electrolyte as in claim 8, wherein the block copolymer is a diblock copolymer.

35. A polymer electrolyte as in claim 8, wherein the block copolymer is a triblock copolymer.

36. An article comprising:

a dimensionally-stable, interpenetrating microstructure of a first phase including a first component and a second phase, immiscible with the first phase, including a second component, the first and second components each polymeric, the first and second phases defining interphase boundaries therebetween; and

at least one particle positioned between a first phase and a second phase at an interphase boundary.

37. An article according to claim 36, wherein the or each particle is an ion host material.

38. An article comprising an electronically-conductive polymer, an ionically-conductive polymer and a plurality of ion host particles in electronic communication with the electronically-conductive polymer and in ionic communication with the ionically-conductive polymer and wherein the electronically-conductive polymer and the ionically-conductive polymer form a dimensionally-stable, bicontinuous, interpenetrating polymeric microstructure, the polymeric microstructure including an electronically-conductive phase defined by the electronically-conductive polymer, and an ionically-conductive phase defined by the ionically-conductive polymer immiscible with the electronically-conductive phase, the electronically-conductive and ionically-conductive phases defining a phase boundary therebetween, and the ion host particles positioned between the electronically-conductive phase and the ionically-conductive phase at the phase boundary.

39. A method of making an article, comprising:

creating a solution including a first component and a second component and at least one particle; and

allowing the solution to solidify and the first component to phase separate from the second component to form an interpenetrating microstructure of a first phase including the

first component and a second phase, immiscible with the first phase, including the second component, and the at least one particle to migrate to and be positioned at an interphase boundary defined between the first and second phases.

40. A solid state polymer electrolyte battery assembly comprising:

an anode;

a cathode;

a first electrolyte in ionic communication with each of the anode and cathode; and

an external circuit in electronic communication with each of the anode and cathode, wherein at least one of the anode or cathode comprises a bicontinuous, interpenetrating microstructure of a first, electronically-conductive component, a second, ionically-conductive component immiscible with and phase-separated from the electronically-conductive component at typical battery service temperatures, and ion host particles positioned at interphase boundaries between the electronically-conductive and ionically-conductive components.

has to have ion host

41. A solid state polymer electrolyte battery assembly as in claim 40, wherein the first component is an electronically-conductive polymer and the second component is a second, block copolymeric electrolyte.

42. A solid state polymer electrolyte battery assembly as in claim 40, wherein the electronically-conductive and ionically-conductive components are selected so as to be able to form an interpenetrating structure induced by spinodal decomposition resulting from quenching of a melt or evaporation of a solvent from a solution of the two components.

43. A solid state polymer electrolyte battery assembly as in claim 40, wherein at least one of the first and second components has a cross-sectional dimension of from about 0.05 microns to about 200 microns.

44. A solid state polymer electrolyte battery assembly as in claim 43, wherein at least one of the first and second components has a cross-sectional dimension of from about 0.1 microns to about 100 microns.

45. A solid state polymer electrolyte battery assembly as in claim 40, wherein the electronically-conductive component is selected from the group consisting of polyacetylene, poly(1,4-phenylene vinylene), polyaniline, sulphonated polyaniline, *trans*-polyacetylene, polypyrrole, polyisothianaphthalene, poly(*p*-phenylene), poly(*p*-phenylenevinylene), polythiophene, and poly(3-alkyl-thiophene).

46. A solid state polymer electrolyte battery assembly as in claim 40, wherein the ion host particles are obtainable by participation in an ion metathetical reaction.

47. A solid state polymer electrolyte battery assembly as in claim 40, wherein the ion host particles comprise Ag_2WO_3.

48. A solid state polymer electrolyte battery assembly as in claim 40, wherein the cathode comprises the bicontinuous, interpenetrating microstructure and includes lithium ion host particles from which withdrawal of lithium ions and electrons is energetically unfavorable.

49. A solid state polymer electrolyte battery assembly as in claim 48, wherein the ion host particles comprise $LiCoO_2$.

50. A solid state polymer electrolyte battery assembly as in claim 48, wherein the ion host particles comprise metal dichalcogenides.

51. A solid state polymer electrolyte battery assembly as in claim 48, wherein the ion host particles comprise $Li_xM_yN_zO_2$, in which x, y and z are all numbers from about 0 to about 1, and M and N are selected among Zn, Al, Cd and main group elements.

52. A solid state polymer electrolyte battery assembly as in claim 51, wherein the ion host particles comprise $LiZnO_2$.

53. A solid state polymer electrolyte battery assembly as in claim 40, wherein the ion host particles include hosts of ions selected from the group consisting of sodium ions, potassium ions, calcium ions and magnesium ions.

54. A solid state polymer electrolyte battery assembly as in claim 40, wherein the ion host particles include hosts of lithium ions.

55. A solid state polymer electrolyte battery assembly as in claim 40, wherein the ion host particles have a maximum cross-sectional dimension of less than about 80 microns.

56. A solid state polymer electrolyte battery assembly as in claim 55, wherein the lithium ion host particles have a maximum cross-sectional dimension of less than about 20 microns.

57. A solid state polymer electrolyte battery assembly as in claim 56, wherein the ion host particles have a maximum cross-sectional dimension of less than about 1 micron.

58. A solid state polymer electrolyte battery assembly as in claim 57, wherein the ion host particles have a maximum cross-sectional dimension of less than about 500 nm.

59. A solid state polymer electrolyte battery assembly as in claim 58, wherein the ion host particles have a maximum cross-sectional dimension of less than about 100 nm.

60. A solid state polymer electrolyte battery assembly as in claim 59, wherein the ion host particles have a maximum cross-sectional dimension of less than about 10 nm.